for MSS between 1-3 GHz. This should include an analysis of all footnotes, resolutions, recommendations, and provisions of the Radio Regulations applicable to this spectrum.

Technical and Operational Criteria Concerning Existing Services. The informal working group should review any dates associated with certain parts of the radio regulations, coordination triggers, classes of allocation and sharing criteria available within the Radio Regulations, Radiocommunication Bureau's rules of procedure and ITU-R recommendations to determine the adequacy for use with MSS between 1-3 GHz. If necessary
y, the Committee should develop (provide) any other sharing criteria required to maintain compatible operations between the planned MSS between 1-3 GHz and other radio services operating in the allocated frequency bands.

Agenda Item 3(d)

New Allocations Estimate additional bandwidth requirements for MSS between 1-3 GHz and identify preferred frequency bands with a view toward obtaining limited primary or secondary allocations in 1995. To this extent, provide analysis of any necessary technical and/or operational criteria for other services in candidate bands. Indicate the projected time frame within which new allocations will be needed and by which existing services can be reaccommodated if necessary.

Agenda Item 5

Regulatory Provisions. In conjunction with IWG-2 (MSS Below 1 GHz), the informal working group should develop the regulatory provisions necessary to coordinate LEO MSS between 1-3 GHz with other LEO MSS systems and with other co-primary services. To this end, it should evaluate Resolution 46 with a view toward defining those changes (if any) that will be beneficial to the development of the LEO MSS between 1-3 GHz industry. This cm was developed as an interim procedure at WARC-92 and may need further refinement based on experience to date.

3.1 Background

The 1995 World Radiocommunication Conference (WRC-95) provides a timely and appropriate opportunity for improvement of existing MSS allocations and adoption of new MSS allocations.

The 1992 World Administrative Radio Conference (WARC-92) was the first conference since 1971 to allocate new spectrum to MSS. These additional allocations, below 1 GHz, in the 1-3 GHz range and at 20/30 GHz, were agreed to only at the end of the conference and required a great deal of compromise. The U.S. was the leading proponent of the new allocations; the CEPT countries were the leading opponents of the new allocations. Included among the compromises were such matters as relatively restrictive power limits on MSS systems that will be required to share certain of the bands with other services, limiting certain allocations to particular regions and countries, and the establishment of implementation dates that are as late as 2005 for MSS operations in certain of the new bands. Several resolutions were adopted that specifically noted the need for further study of the potential for sharing of the bands allocated to MSS.

Since the conclusion of WARC-92, there has been a good deal of further analysis in the ITU-R Study Group process and elsewhere of the utility of the different bands and the potential for sharing the band with other services. Those studies are showing that sharing in certain of the bands may be done with fewer restrictions than agreed to in 1992 and, in other cases, that sharing will be more difficult or impossible. In addition, it has become evident since the conference that demand for the new allocations is substantial and continues to grow as new MSS systems continue to be proposed and planned systems continue to progress in their development.

Recognizing the immediate need to deal with MSS matters, the 1993 World Radiocommunications Conference (WRC-93) agreed to include on the agenda of WRC-95 the improvement of existing MSS allocations and, if necessary, the allocation of new MSS spectrum. Thus, WRC-95 presents an opportunity for the U.S. to continue its leadership role in MSS.

The 1993 Radiocommunication Assembly decided that preparatory studies for a WRC are to be carried out by a Conference Preparatory Meeting (CPM). The CPM for each conference will normally hold two meetings prior to a WRC. The first such meeting (CPM-94) organized and coordinated preparatory studies and developed the outline of the Report to WRC-95. CPM-95 met in Geneva March/April 1995 and prepared the final CPM Report to WRC-95.

3.2 Spectrum Requirements

3.2.1 Existing MSS Spectrum Requirements

The existing use of MSS allocations in the range 1-3 GHz are required for both GSO and NGSO MSS service links. The GSO systems are located in the bands 1525-1559 MHz and 1626.5-1660.5 MHz. The principal U.S. operators having systems in these allocations are AMSC and COMSAT Mobile Communications.

The U.S. NGSO MSS systems which have received licenses are IRIDIUM (Motorola), GLOBALSTAR (Loral\Qualcomm) and Odyssey (TRW). Ellipsat (MCHI), AMSC and Constellation Communications are awaiting licenses. These systems will operate in the bands 1610-1626.5 MHz and 2483.5-2500 MHz. Personal Communications Satellite Corporation and Celsat Inc. have applied to construct GSO MSS systems in the 2 GHz MSS allocations.

As indicated in the bar chart provided by the CPM, the allocations indicated above have the greatest current and proposed use, i.e., B8 & B10 for GSO MSS and B9 & B14 for NGSO MSS. The chart shows the worldwide use of these allocations.

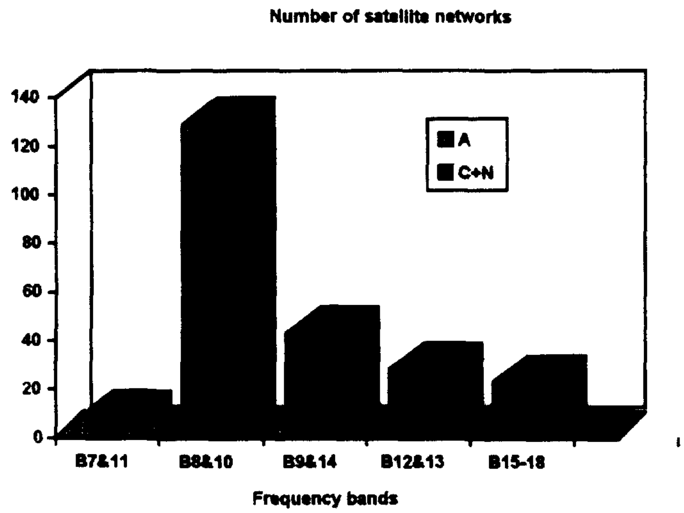


Figure 3.2.1 - Existing and Planned MSS Networks

Legend for Frequency Bands:

B7 1492-1525 MHz	B13 2160-2200 MHz
B8 1525-1559 MHz	B14 2483-2500 MHz
B9 1610-1626.5 MHz	B15 2500-2520 MHz
B10 1626.5-1660.5 MHz	B16 2520-2535 MHz
B11 1675-1710 MHz	B17 2655-2670 MHz
B12 1970-2010 MHz	B18 2670-2690 MHz

3.2.2 Future Spectrum Requirements

Resolution 1 of the Agenda for WRC-95 provides, in resolves 3.d), for the consideration of "requirements for the MSS and associated feeder links and, if necessary, adopt in 1995 limited allocations." Because of the recent introduction of MSS, it is essential to provide justification for allocations sought to meet future spectrum needs of MSS above 1 GHz.

MSS demand forecasts, primarily as provided in public domain market studies of MSS and terrestrial mobile services, have been used to establish a benchmark projection for MSS usage in the year 2005. The bases for these projections are also provided. The projected user figures are then translated into Erlang (busy) hour traffic, then into equivalent number of voice channels needed to carry that intensity of traffic; and finally, into the required RF spectrum, using the appropriate transmission/modulation and frequency reuse parameters. A range of projected demand, including low, medium and high estimates, is provided.

3.2.2.1 MSS User Projections

(a) Background

While current usage of MSS is relatively low today, this can be attributed to several factors, including: (1) recent introduction of the service; (2) high cost of user terminals ($4,000 and up); (3) relatively high service charges; and (4) other. The use of voice capable MSS systems above 1 GHz is predicted to grow substantially as first, domestic MSS systems such as AMSC are implemented in the mid-1990s, and satellite/cellular systems are introduced in the late 1990s. These systems will enable the use of small transceivers, e.g. cellular telephones, which will ultimately be priced from $200-$500. In fact, much MSS use will be attributed to the use of terrestrial cellular because many terrestrial systems will utilize MSS to extend coverage. Apart from integrated use with terrestrial cellular, MSS systems will be used in areas where no telecommunications is now available, and to facilitate global roaming by cellular users.

Although some critics of mobile satellite service claim that cellular and PCS build-out over the next 10 years will greatly diminish the demand for MSS, these critics do not take account of the fact that terrestrial technologies will never provide service in more than a small fraction of the geographic area of the earth. For example, it is projected that only 15 percent of the world's land masses will be covered by cellular networks by the year 2010. Thus, large geographic areas of the world will remain unserved by cellular communications and a substantial portion of these areas will remain unserved by any telecommunications infrastructures.

Market and other studies in the public domain have been used to assess projections of MSS demand in the year 2010. These studies project demand growing from a base of 3 to 4 million MSS subscribers in 2002 to 8-13 million by 2005, and 22 to 37 million by 2010.

(b) Basis for MSS Service Projections - Target Markets

Mobile satellite service (MSS) systems have been designed to provide global, ubiquitous telecommunications to anyone at any time, in any location. Services will include mobile voice, fax and data. In regions where cellular systems are prevalent, MSS will provide a "value added" service to cellular networks. In effect, cellular service providers will be able to extend their range of coverage by using MSS when implementation of additional terrestrial cell sites is impractical or prohibitively expensive.

Most MSS systems propose to offer dual-mode, cellular/satellite terminals which will allow the user to operate his or her terminal on either a cellular or satellite frequency. Thus, when the phone will search for the strongest signal before originating a call. When a terrestrial system is in range, the terminal will select that system. When the terrestrial system signal is not detected, or is too weak, the terminal will select a pre-designated satellite system. The benefit of the dual-mode phone is that users will obtain access to both terrestrial mobile and satellite mobile service, enabling them to take benefit of the likely lower costs terrestrial service, when available. Users may operate their handsets on the local cellular network, and on other cellular networks available through roaming agreements. The MSS service will be utilized where no cellular coverage is available and where no roaming agreements permit use of an existing cellular system.

Research undertaken by MSS operators, as well as independent analysts, have identified the following three markets for MSS service: (1) cellular fill-in market consisting of those users who require mobile services in rural parts of the developed world and in rural/urban areas of countries where terrestrial cellular coverage may be limited; (2) the international business traveler market consisting of professionals who travel to regions with incompatible or limited cellular or PSTN services; and the semi-fixed user market consisting of users requiring services in urban and rural areas of countries which lack PSTN. MSS will be used as both a complement and a supplement to terrestrial mobile telecommunications services, including cellular and the PSTN. The following provide some of the reasons why MSS will fulfill this complementary role:

(1) cellular coverage - by the year 2000, approximately 55% of the world's population will be covered by terrestrial cellular systems. This leaves almost half of the world's population uncovered. In addition, by the year 2000, only 15% of the world's land masses will be covered by terrestrial cellular systems, thereby leaving 85% of the world's land masses uncovered by terrestrial mobile communications, and, in many cases, any communications infrastructure. Additional terrestrial cellular coverage is projected to be minimal, beyond these figures, because it will not be economically feasible to place cellular networks in areas of low-population density or where such networks cannot be supported by the local economy.

(2) roaming - although terrestrial cellular providers have increasingly sought to enter into roaming agreements and to reduce the complexity of roaming protocols for cellular subscribers, roaming has remained exceedingly complex and costly. Roamers generally must pay for cellular use by credit card, because subscriber validation is not available in roaming situations. Even though nationwide cellular roaming will become increasingly more available and less complicated, international roaming from one terrestrial network to another is unlikely to be implemented in a user-friendly manner.

(3) pricing - although the price for MSS service may range from 50 cents per minute to $3 per minute, depending on the communications alternatives, which may include hotel surcharges and high international rates, MSS service may be considered price competitive in many situations.

(4) availability of the subscriber - MSS services will allow the subscriber to be reached at any time, in any location, with one number.

(5) ease of operation - a current impediment to the use of telecommunications service may be not only the lack of availability of a local network, but the lack of availability of a terminal, such as a phone set or telephone booth. With a dual-mode MSS handset, the subscriber is always capable of placing a call.

The size of the individual market segments identified (cellular fill-in, international business traveler, and semi-fixed user market) will be dependent on a number of factors including the date of introduction of handheld services, the coverage provided by the systems, ease of use, and terminal and user charges. Some of the MSS systems will focus their business and market strategies towards one or two of these segments.

(c) Traffic Volume

The range in applications complicates the task of projecting the number of minutes per subscriber. In situations where MSS is used primarily for extension of terrestrial cellular systems, the number of minutes per year on the satellite system might be smaller than in the case of the international business traveler, and in the case where MSS service is the primary or only telecommunications service available. Based on the market studies reviewed, a reasonable number of minutes per subscriber, on average, would be in the range of 800-1200 minutes per year.

(d) MSS User Projections

The existing market studies provide a range of user projections for MSS:

MSS Subscriber Projections

Projection (millions)	Date	Study
22	2004	IRD
4.11	2003	PCIA
15.0	2004	LTA
6.0	2004	Peat Marwick

(e) Total Peak Spectrum Requirements for Handheld Non-GSO MSS Spectrum for Personal Communications

Following is the methodology used to calculate the total bandwidth requirements to meet projected MSS needs. To arrive at the bandwidth requirement, the peak traffic stream to be supported by the systems must be estimated. The peak traffic stream will depend on the calling characteristics of users over periods of time, including a day, week, month and a year.

Using the methodology, the following spectrum requirements for MSS, in the year 2005, can be developed for handheld (voice) PC/MSS forecast markets:

Market Estimate	Subscribers Millions	Equivalent Spectrum Requirement (each direction) for Handheld Voice Personal Communications MSS
Low	4.11	19.3 MHz
Low	6.0	28.1 MHz
Medium	15.0	70.2 MHz
High	22.0	103 MHz

Note: these estimates do not include spectrum requirements needed to meet "conventional" GSO MSS needs.

(f) Total "Conventional" GSO MSS Spectrum

Based on inputs to ITU-R Task Group 8/3 made by INMARSAT, first in the Toronto meeting, July, 1994, and more recently in Geneva, the forecasts for so called "conventional" MSS (ie, non-handheld PC/MSS, most likely provided by GSO satellites) have been revised downward, to take account of the likely cross-impact to certain conventional MSS markets (particularly land mobile services) which would likely migrate to handheld Non-GSO systems when these more convenient services are available towards the end of the century.

Thus, to compare these projections to the ITU-R, Joint Interim Working Party preparing for WARC-92 (JIWP-92), the JIWP-92 forecast the following spectrum requirements for each direction, in the year 2010, including a speculative value for LMSS which may have included considerable overlap between "conventional"-GSO and handheld non-GSO:

Service	Minimum Requirement (MHz)	Likely Req't (MHz
AMS (R) S	14.5	17.5
Other AMSS	15.0	18.0
LMSS	41.3	87.6
MMSS	17.0	40.0
Distress/Safety	1.0	1.0
TOTAL	88.8 MHz	164.1 MHz

With the cross-impacts for LMSS factored in, the INMARSAT contributions provided a more realistic forecast for Conventional MSS Spectrum Requirements (excluding PC-MSS) served as a correction to the original JIWP Report:

Service	Lower Bound MSS Non-Handheld (MHz)	Realistic MSS Non-Handheld (MHz)
Aero Total	29.5	35.5
LMSS	13.8	29.2
Maritime	17.0	40.0
Distress/Safty	1.0	1.0
TOTAL	61.3 MHz	105.7 MHz

The most recent forecasts for conventional MSS have also been truncated to about the year 2005, due to the uncertainties associated with projecting annual growth rates much beyond a 10-year planning horizon. Using the "Realistic" (higher) forecast, this results in a spectrum requirement of approximately 86 MHz in each direction, for GSO MSS.

(g) Total MSS Spectrum Forecast: Conventional MSS (GSO) + Handheld (NGSO)

Because of the uncertainty of long range forecasts, the total spectrum requirements for MSS should be estimated only out to the year 2005, as suggested in the most recent report of ITU-R Task Group 8/3. Taking the INMARSAT inputs to TG 8/3 as the basis for conventional MSS, while using market studies referred to above for handheld PC-MSS (provided by Non-GSO systems), the total "minimum (lower bound)" and "likely (realistic)" spectrum requirements will range from around 150 MHz (2 x 75) to 300 MHz (2 x 150) by the 2005. (see Figs 1-3 for growth curves)

References:

Satellite Personal Communications and their Consequences for European Telecommunications, Trade and Industry, KPMG Peat Marwick Report to the European Commission, March, 1994.

Wireless Electronic Mail and Facsimile Markets Worldwide, International Resource Development, Inc., November, 1993.

The Market for Mobile Satellite Services: Prospects for LEOs and GEOs, Leslie Taylor Associates, June, 1994.

Developments on the Mobile Data Communications Market, Arthur D. Little Inc., June, 1992.

Portable Computers & Wireless Communications, DataComm Research, Third Quarter, 1993.

INMARSAT in the 21st Century, Mary Ann Elliott and Betsy Kulick, 1994.

FIGURE 3

MSS CONVENTIONAL + PERSONAL COMMUNICATION SERVICES : FORECASTED SPECTRUM REQUIREMENTS IN EACH DIRECTION AGAINST MAXIMUM WORLDWIDE SPECTRUM ALLOCATIONS

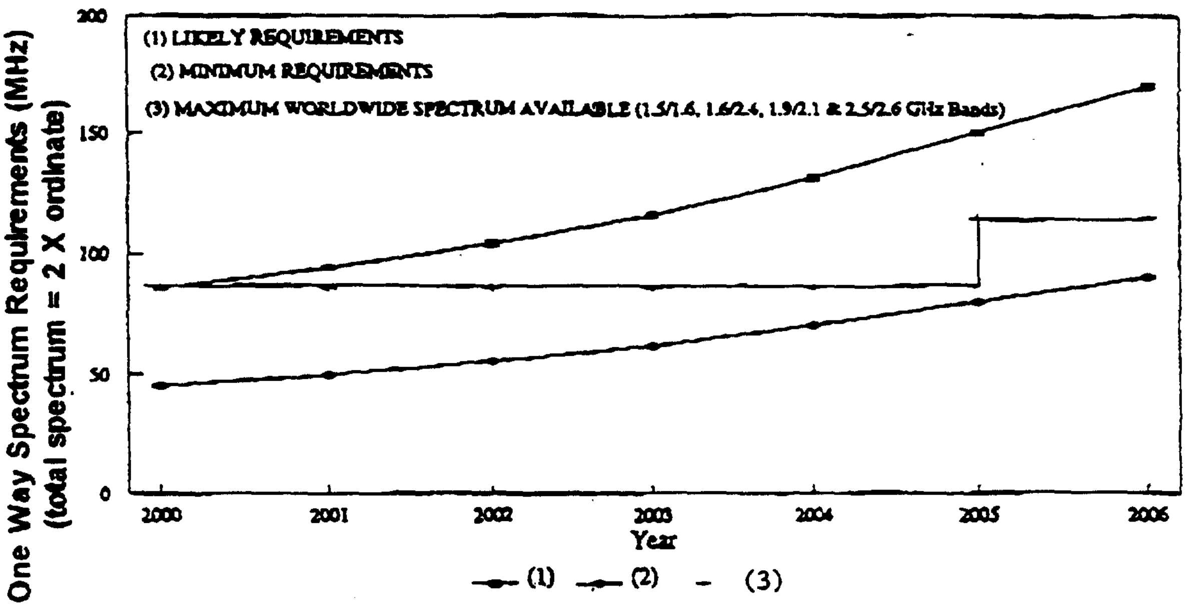


FIGURE 2
MSS CONVENTIONAL SERVICES:
JIWP FORECASTED LIKELY SPECTRUM REQUIREMENTS IN EACH DIRECTION AGAINST MAXIMUM WORLDWIDE SPECTRUM ALLOCATIONS
MSS PERSONAL COMMUNICATION CROSS IMPACT FACTORED INTO LMSS ESTIMATES

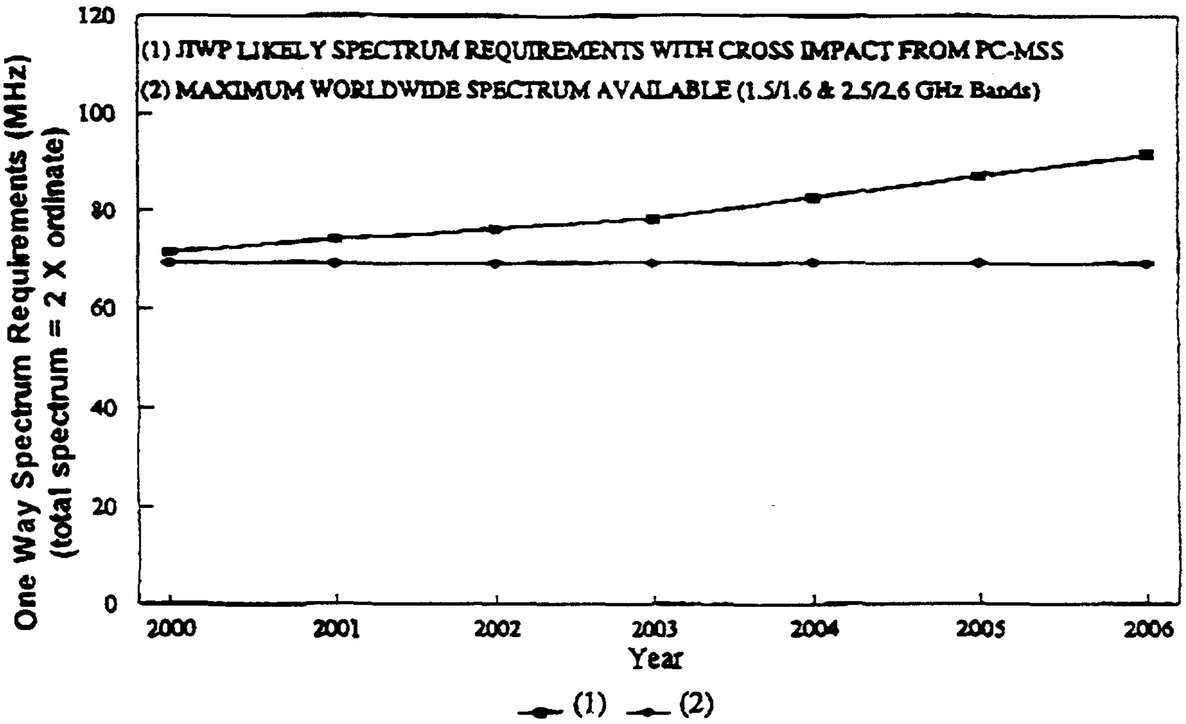
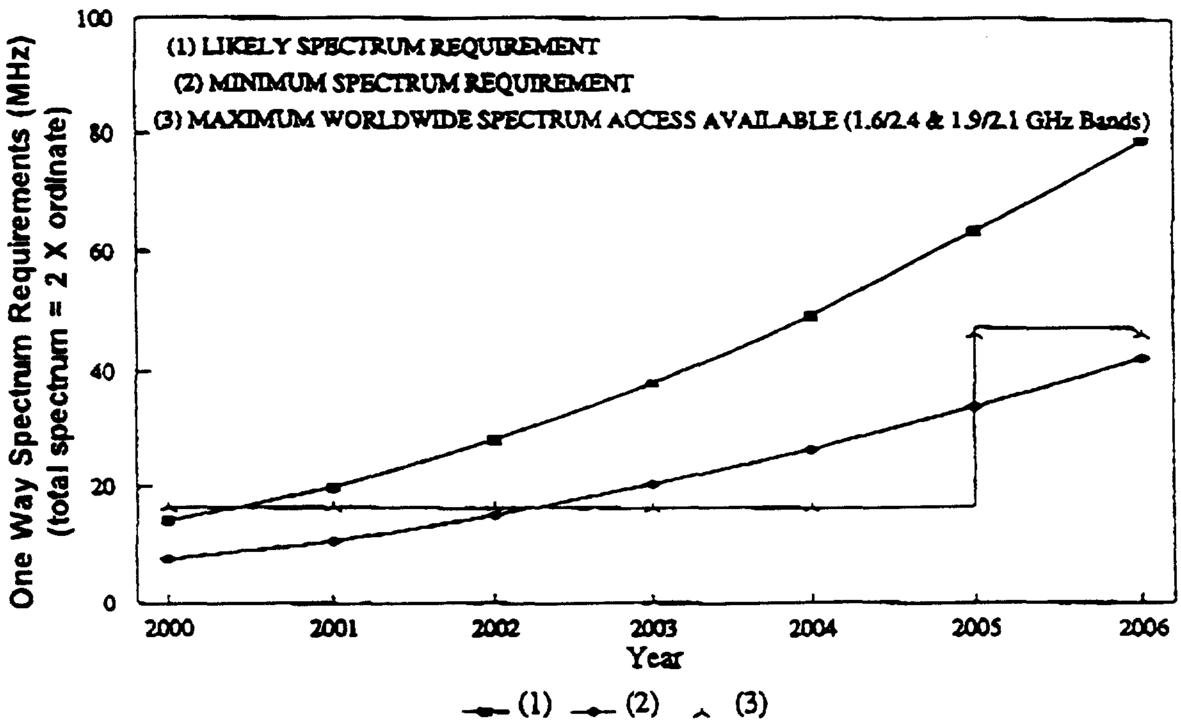


FIGURE 1
MSS PERSONAL COMMUNICATION SERVICES :
FORECASTED SPECTRUM REQUIREMENTS IN EACH DIRECTION AGAINST MAXIMUM WORLDWIDE SPECTRUM ALLOCATIONS



000130

In the initial report of its long range strategic spectrum planning project, U.S. National Spectrum Requirements: Projections and Trends, NTIA projects that 60 MHz of additional spectrum will be needed to meet MSS traffic requirements in the United States, to serve an estimated 3.3 million users, by the year 2004. This estimate does not consider MSS spectrum requirements for service outside U.S. territory. The latter foreign spectrum requirements are additive to those for the U.S. as a result of frequency sharing and reuse limitations in the MSS.

3.2.2.2 Method for Converting MSS Voice Traffic Demand Forecasts into Spectrum Requirements (MSS Networks Above 1 GHz)

(a) Introduction

The Conference Preparatory Meeting (CPM) requested that TG 8/3 develop estimates of projected MSS service-link spectrum requirements. TG 8/3 received contributions from Administrations on MSS traffic forecasts the future estimated demand for MSS. This document lays out a simplified methodology for converting MSS traffic forecasts into equivalent spectrum requirements.

(b) Conversion Method: Classical CCITT Method

Within the CCITT, Recommendation E.506, Forecasting International Traffic, includes an Annex (A) with a classic, composite-ratio method for converting the annual or monthly total paid-minutes of international traffic into the estimated mean carried busy-hour traffic (in Erlangs) using the formula:

$$A = (M*D*H) / (60*E) \qquad (1)$$

where:

A = the estimated mean traffic in Erlangs (busy-hour)

M = total monthly paid-minutes

D = busy day/month ratio

H = busy-hour/day ratio

E = efficiency factor; i.e., the ratio of busy-hour paid-time to busy-hour occupied time. Forecasts of efficiency can be made from extrapolation of past trends, generally in the range of .8 to .9, depending on signalling system characteristics.

3.2.2.3 Steps to applying CCITT Classical Method

For new types of systems or services, data may not be available for total monthly paid-minutes. In this case, the value M may be taken as the product of the estimated number of subscribers, $N_{subscribers}$, and the estimated average number of minutes of use per month for an average subscriber, MOU. For this purpose, values of D, H, E can be estimated from a comparable existing service.

From this point, two additional steps are needed to determine the RF spectrum requirements. First, Erlang peak busy-hour traffic must be converted into the equivalent number of voice channels, with the required percentage of blocking, or grade of service, via the standard Erlang-B Tables or graphs; using a known design for the grouping of traffic streams or trunks, which would generally construed to be individual transponder beams in the case of satellites. Second, the voice channel loading must then be converted into RF bandwidth, using standard transmission parameters; e.g., equivalent bandwidth/channel.

(c) Simplified Method to Determine the MSS Spectrum Requirements

The starting point for this method is a simplified version of the classical CCITT conversion formula and the subsequent two-step method outlined above.

This section describes the overall logic used to convert the MSS traffic demand into the required radio frequency (RF) spectrum. The formulas presented below are directly applicable only to FDMA systems. These equations can be adapted for TDMA and/or CDMA by the addition of other factors; such as, in the case of CDMA, the pseudo-random noise chipping rate and the self-jamming noise contribution. The equations are based on input documents to ITU-R Task Group 8/3 made by the U.S. and INMARSAT.

The first block of data taken from the MSS market studies is used to derive the total global traffic load in terms of "Erlangs offered during the peak hour" denoted as Aww in the following formula:

$$Aww = (N_{subscribers} * MOU) / (60*M*D*H*E) \qquad (1')$$

Note that H, the ratio of peak hour traffic to daily traffic, is typically on the order of 10%.

Next, parameters are used to convert the worldwide Erlang loading into the number of voice channels needed to carry that level of traffic. The Erlang-B equation tables are used to provide the relationship between traffic level offered, grade of service (blocking probability) and number of channels in the trunk group. To simplify the calculation, we assume the number of channels is equal to the number of Erlangs of traffic (1 channel per Erlang), which is justifiable for satellites carrying 100 or more channels per spot beam (consider a spot beam as a trunk group):

$$Nc = Aww * Erlang \qquad (2)$$

The third block of parameters are used to calculate the RF bandwidth needed to transmit each voice channel for digital transmissions by the following equation:

$$Bc = \text{Rvocoder} * ((1 + \text{Foverhead}) / \text{Rfec}) * \text{Fm-ary} * (1 + \text{Fguard}) * (1 + \text{Fsig}) \ldots\ldots(3).$$

where:

Bc =	Bandwidth per channel
Rv'r =	Output bit rate of vocoder
Fo'd =	Channel overhead factor as the ratio of framing and in-channel signalling bits to vocoder bits
Rfec =	Forward error correction rate
Fm-ary =	Conversion factor from bits to Hz
Fguard =	Guard band factor as a fraction of the occupied bandwidth of the channel
Fsig =	Ratio of signalling channels to working (traffic bearing) channels

The total worldwide bandwidth (in MHz) required per beam is given by the formula:

$$Bww = Nc * Bc * 10\text{-}6$$

Bww, Total bandwidth requirement . . . . (4)

Finally, the total RF spectrum for voice services required to satisfy the overall demand, denoted by $Sreq\_^{v}$ is calculated from the following formula:

$$Sreq\_^{v} = Bww * (1/Ffp) * (1/Nb) * \text{Fhotspot} * \text{Nreuse} \ldots\ldots (5)$$

$Sreq\_^{v}$ =	Total spectrum requirement for voice traffic
Ffp =	Frequency planning efficiency factor
Nb =	Number of satellite beams covering the world's area that generates the traffic
Fh't =	Hot spot factor
Nreuse =	Number of beams in frequency repetition factor

Equation (5) is an approximation which takes into account the geometric factors relating to the way spectrum is assigned to individual spot beams and the practical levels of frequency reuse attainable within a given NGSO satellite. This, in turn, depends on factors such as the area of visibility of the earth , as viewed by the satellite (at a given orbital altitude), the number of spot beams per satellite, and the number of beams which cannot re-use frequencies because of their overlap with adjacent beams on the same satellite or other satellites which illuminate the same geographic areas of the earth. Unfortunately, these factors are highly configuration dependent on the system parameters of the different NGSO constellations. This formula uses an empirically derived "hot-spot factor" to take account of non-uniform distribution of traffic over the world's land area as a function of the different satellite altitudes and varying number of spot beams which are used and the consequential effective frequency reuse attained on these systems. Table I provides a range of values for the "hot-spot factor" for GSO/ICO/LEO type MSS systems. A conceptual discussion of satellite spot-beam frequency reuse, geographic distribution of traffic and several other pertinent factors is provided below.

(d) Discussion and Conclusion

The general methodology is outlined in this section, in the stated analytical formulas, may be used to convert a traffic forecast for a particular MSS service into a peak Erlang requirement. Thus, a given level of forecast "traffic intensity" or Erlangs is converted into the equivalent number of voice channels (overall worldwide requirement for MSS), using a certain grade of service with the use of the Erlang conversion formula. The conversion formula takes into account the composite peak to average ratio. In the estimation process, a given ratio can be substituted into the formula based on experience from existing MSS or cellular operators. Subsequently, the calculated voice channel loading can be converted into a bandwidth requirement using the appropriate transmission parameters; e.g., modulation type, encoder bit rate/voice channel, forward error control (FEC) rate, channel spacing, including guard bands with practical filtering.

3.2.2.4 Other Factors

In order to accurately estimate the overall MSS service-link spectrum requirements, several other factors must be taken into account. Most important of these is the level of frequency reuse attainable by a given MSS system. The frequency reuse factor, in turn, will depend on: (1) satellite spot-beam reuse factor; (2) mobile earth stations (MES) isolation; and (3) the geographic distribution of traffic.

(a) Satellite Spot-Beam Reuse

All the MSS systems being proposed to date (GSO or NGSO) make use of a number of spot beams which are sufficiently isolated from each other (in geographically separated coverage areas) to allow the same group of carrier frequencies to be re-assigned F reuse times among a pattern of different spot beams (usually non-adjacent beams). This allows reuse of the spectrum, so that the total bandwidth requirement can be divided down by F reuse -to yield the net overall spectrum requirement. An average level of global frequency reuse must be assumed in this model. This, in turn, will depend on the geographic distribution of traffic. (see 4.3)

(b) Mobile Earth Station (MES) Isolation, if any

In existing maritime/aeronautical and some land mobile earth stations, medium to high-gain, directive antennas are used. This provides a level of off-axis discrimination in the direction of the unwanted satellite network. Particularly for wide-spaced GSO/MSS networks, this MES antenna isolation may allow co-channel or staggered-channel frequency reuse, even without reliance on any spot beam isolation. However, for handheld MSS services, MES portability and small size are of paramount importance, so these MSS services will typically employ near omni-directional antennas. This means that it is extremely unlikely that frequency reuse by virtue of MES off-axis isolation will be attainable in overlapping coverage areas between adjacent satellites in GSO or NGSO satellites serving common or overlapping coverage areas. To be conservative, no advantage in MES isolation should be assumed in applying this model.

(c) Geographic Distribution of Traffic

The net level of frequency reuse that can actually be achieved by an MSS system is also dependent on the geographic distribution of traffic over the spot beam coverages of the satellite. For initial purposes of this model, one could assume a uniform distribution of traffic over the world (or land-mass areas of the world). However, in reality, market studies done to date indicate that the major demand for MSS personal communications is really concentrated in the Western Hemisphere, certain developing countries and in the Asia Pacific region. This concentration of traffic in certain countries or geographic regions will have the effect of limiting the actual level of frequency reuse that can be attained, regardless of the theoretical level that would be possible with the spot beam reuse patterns and an assumed uniform traffic distribution. This is because the channels/beam will be very low in spot beams covering certain regions and never approach the maximum capacity the system is capable of providing in those beams; whereas, the traffic loading will actually hit or exceed the maximums in particular spot beams over the peak traffic areas.

WRC-95 agenda item 2.1(a) calls for the review of the technical constraints associated with the frequency bands allocated below 3 GHz to MSS and associated provisions, resolutions and recommendations with a view towards facilitating the use of these bands by MSS with due regard to existing services.

As a result of WARC-92, up to 399 MHz of spectrum between 1 and 3 GHz is currently allocated to MSS, although the bandwidth and status (primary or secondary) of some of the MSS allocations vary among the three Regions. Only 201 MHz is allocated on a worldwide co-primary basis to MSS. Moreover, the usability of these bands by new or expanded MSS systems is limited by existing usage and by various regulatory provisions described below.

3.3.1 Usability of Bands

This section of the report provides a preliminary review of the current MSS allocations between 1 and 3 GHz. Similar reviews have been conducted in other areas and the results of those studies have been incorporated into this report.

(a) Possible Use Of The Bands Allocated

Table 3.3.1-a lists the bands between 1 and 3 GHz that are currently allocated to MSS, including a brief summary of the allocation status, sharing conditions and MSS usage. More specific details concerning these bands are provided in the following paragraphs.

1492-1525/ MHz. WARC-92 allocated this band on a primary basis to MSS only in Region 2. The 1492-1525 MHz band is not currently available for MSS use in the United States (see RR No. 722C) because of potential interference to existing aeronautical telemetry operations. The sharing conditions in this band are addressed in Section 3.3.2.4.

1675-1710 MHz. WARC-92 allocated this band on a primary basis to MSS only in Region 2. This band is currently used for meteorological aids and meteorological satellites on a worldwide basis. The feasibility of implementing MSS systems in this band is addressed in Sections 3.3.2(a)3 and 3.3.2(g) below.

1525-1559/1626.5-1660.5 MHz. These bands have been allocated for MSS since the 1971 WARC, although adjustments to the MSS allocations were made by subsequent conferences in 1979, 1987 and 1992. MSS systems, such as MARISAT and INMARSAT, have been operational in the lower portion of these bands since the mid-1970s, and the American Mobile Satellite Corporation has been licensed to operate a domestic MSS system in the upper portion of these bands. The allocation structure of these bands is complex, with different portions allocated to the mobile-satellite service, the maritime mobile-satellite service, the aeronautical (R) mobile-satellite service, and the land mobile satellite service. There are a large number of other geostationary MSS systems planned or operating in these bands, and the ongoing coordination of all of these MSS systems is proving to be very difficult.

1610-1626.5/2483.5-2500 MHz. These bands were initially allocated to the radiodetermination-satellite service by the 1987 WARC. Worldwide primary MSS allocations were adopted by WARC-92, primarily to accommodate the then newly proposed non-GSO MSS systems. The sharing conditions in these bands are complex as reflected by the numerous footnotes to these bands in the Table of Allocations. A detailed examination of all of these sharing conditions was conducted during the proceedings in CC Docket No. 92-166 and the results are reflected in the recent amendments to Part 25 of the FCC's Rules and Regulations adopted by the Report and Order (FCC 92-261) released October 14, 1994 in that proceeding. The FCC is expected to issue licenses for several non-GSO MSS systems in these bands in early 1995.

1930-1980/2120-2170 MHz. WARC-92 allocated these bands only in Region 2. However, only 10 MHz of each band is allocated on a primary basis to MSS, the other 40 MHz being allocated to MSS on a secondary basis. These bands are heavily used by terrestrial services and the utility of these bands for MSS will depend on the results of the sharing studies being conducted with respect to the fixed and mobile services currently operating in these bands. Moreover, recent FCC decisions concerning the auctioning of spectrum for PCS in the United States has substantially reduced the likelihood of that United States MSS systems could be operated as a practical matter in the 1970-1980 MHz portion of these band.

1980-2010/2170-2200 MHz. These WARC-92 MSS allocations fall within the bands identified in RR No. 746A for worldwide implementation of FPLMTS, and these bands are often assumed to be the bands in which the satellite component of future PCS systems would eventually be implemented. These bands are heavily used by terrestrial services and the utility of these bands for MSS will depend on the results of the sharing studies being conducted with respect to the fixed and mobile services currently operating in these bands Moreover, recent FCC decisions concerning the auctioning of spectrum for PCS in the United States has substantially reduced the likelihood of that United States MSS systems could be operated as a practical matter in the 1980-1990 MHz portion of these bands.

2500-2535/2655-2690 MHz. The 2500-2535 MHz (space-to-earth) and 2655-2690 MHz (earth-to-space) bands are used in the United States primarily for Instructional Fixed Television Service (ITFS) and Multichannel Multipoint Distribution Service (MMDS). At WARC-92, the bands were allocated for MSS use as well.

The U.S. wanted this allocation limited to Region 1 and Region 3 to prevent interference with ITFS and MMDS in the United States. Although this allocation was not limited by regions, a footnote was added to the allocation table limiting the use of these bands to national boundaries. Moreover, the coordination procedures of Resolution No. 42 (WARC-92) ensure that interference to U.S. operations in the subject bands from planned MSS systems can be prevented. At WRC-95, the U.S. needs to ensure that the footnote limitation of MSS to national boundaries and suitable coordination provisions be retained in order to protect U.S. ITFS and MMDS operations.

(b) Need For Improvement Of Band Use

Section 3.3.3 below addresses the desirability of generic MSS allocations throughout the 1525-1559 MHz and 1626.5-1660.5 MHz MSS bands, and section 3.4 below addresses the dates on which MSS use can be made of certain of these bands. Changes to certain footnote provisions of some of these MSS allocations are also desirable and are discussed in this section of the report.

ALLOCATED BAND (MHZ)	MSS ALLOCATION STATUS	SHARING CONDITIONS SUMMARY	MSS USAGE
1492-1525 (downlink)	33 MHz Region 2 (primary)	Fixed Mobile	Not available in U.S. due to aeronautical telemetry in downlink band;
1675-1710 (uplink)	35 MHz Region 2 (primary)	MetAids, Metsat, fixed and mobile	MetAids and Metsat currently in operation in uplink band: no current MSS systems
1525-1559 (downlink) 1626.5-1660.5 (uplink)	34 MHz Worldwide (primary)	Sharing with fixed in certain countries under RR 730; some sub-bands subject to sharing.	Heavy usage by current and planned GSO MSS systems
1610-1626.5 (uplink) 1613.8-1626.5 (downlink) 2483.5-2500 (downlink)	16.5 MHz Worldwide (primary uplink) 11.7 MHz Worldwide (secondary downlink) 16.5 MHz Worldwide (primary)	Aeronautical radionavigation (including satellites), radioastronomy, and fixed in certain countries under RR 730 in uplink. Fixed, mobile, ISM, radiolocation in downlink.	Multiple non-GSO MSS/RDSS systems planned for these bands.
1930-1980 (uplink) 2120-2170 (downlink)	50 MHz Region 2 (40 MHz secondary) (10 MHz primary)	Fixed Mobile	No current MSS usage
1980-2010 (uplink) 2170-2200 (downlink)	30 MHz Worldwide (primary)	Fixed Mobile	No current MSS usage
2500-2535 (downlink) 2655-2690 (uplink)	20 MHz Worldwide (primary) 15 MHz Worldwide (primary footnotes for national systems)	Fixed Mobile BSS FSS	No U.S. plans due to heavy MMDS usage

Table 3.3.1-a. MSS Band Summary

(i) 1610-1626.5 MHz

Although the international Table of Frequency Allocations provides a primary status to the mobile-satellite service (Earth-to-space) (MSS) in all three Regions in the 1610-1626.5 MHz band, footnotes RR Nos. 731E and 733E contain language that appears to be in contradiction to the primary status of MSS.

Specifically, RR No. 733E states that:

> Harmful interference shall not be caused to stations of the radio astronomy service using the band 1610.6-1613.8 MHz by stations of the radiodetermination-satellite and mobile-satellite service. (No. 2904 applies.)

while the last sentence of RR No. 731E states that:

> . . . Stations of the mobile-satellite service shall not cause harmful interference to, nor claim protection from, stations in the aeronautical radionavigation service, stations operating in accordance with the provisions of No. 732 and stations in the fixed service operating in accordance with the provisions of No. 730.

This footnote text is essentially the same as the text used in the definition of a secondary service in RR Nos. 420-423. This text is unnecessary and redundant to protect the primary status of the other services in the bands. Moreover, the apparent contradiction between this footnote text and primary table status is likely to cause confusion and difficulties in the application of the Resolution 46 coordination procedures for U.S. MSS systems in this band.

RR No. 733E was originally adopted by the 1987 WARC as a Region 1 and 3 footnote at a time when radio astronomy had only secondary status worldwide and the radiodetermination-satellite service (RDSS) was being introduced on a secondary basis in these Regions except for the primary status afforded RDSS in the Region 1 and 3 countries listed in RR No. 733B.

The radio astronomy community feels that the provisions of RR 733E should be retained. The band 1610.6-1613.8 MHz, allocated to the Radio Astronomy Service (RAS) on a Primary basis, is a sub-band of the larger band, 1610-1626.5 MHz, which is allocated to the MSS on a Primary basis. MSS providers expect to utilize the entire 1610-1626.5 MHz band for Earth-to-space transmissions from mobile units using CDMA modulation. Such transmissions may cause harmful interference to the RAS, and in fact render the band useless for radio astronomy in the absence of special coordination measures. RR 733E is a reminder of the need for such coordination measures. For years this special need has been clearly recognized by several international Radio Conferences including WARC-87 and WARC-92, by the VGE of the ITU, which retained RR 733E while deleting other, redundant footnotes relative to the RAS, and most recently by the FCC which, in paragraph 113 of its R&O, adopted the recommendation of the MSS Negotiated Rulemaking Committee by incorporating in its domestic rules the protection of RAS provided by RR 733E.

With the elevation of radio astronomy to primary status in all three Regions at the 1992 WARC, any special recognition intended by the 1987 WARC is no longer needed, especially in light of RR No. 734. In addition, the FCC's recent Report and Order in CC Docket 92-166 adopted rules that provide all the protection needed by radioastronomy in this band. Moreover, although the view has been expressed that the intent of this footnote is to provide protection to radioastronomy from out-of-band emissions caused by MSS transmitters operating anywhere within the 1610-1626.5 MHz band, the provisions of RR No. 344 continue to apply.

Similarly, the contradictory last sentence in RR No. 731E is unnecessary to provide any special recognition of radionavigation services that may have been intended at the 1992 WARC since RR No. 953 continues to apply, particularly in light of ongoing coordination and the recent Memorandum of Understanding between the FCC, NTIA and FAA to resolve these issues. See FCC News, Mimeo 50736, released November 18, 1994.

In addition, footnote 731E states that the e.i.r.p. density of an MSS or RDSS mobile earth station transmitting in the band 1610-1626.5 MHz shall not be in excess of -15dBW/4kHz or - 3dBW/4kHz, depending on whether the emission is in a portion of the band employed by a system operating in accordance with the provisions of RR 732 (e.g. Glonass). There is no indication in the Radio Regulations nor the "legislative" history of this footnote whether these limits should be based on peak or average e.i.r.p. densities.

The FCC, in the Rules accompanying its Big LEO Report and Order, did not clarify this situation However, in regard to out-of-band e.i.r.p. density from the same stations, the new FCC limit is based on an average over a 20 msec period.

The CPM recommended that the e.i.r.p. density limits given in RR 731E should be understood to be a peak e.i.r.p. density of -15 dB(W/4kHz) in the part of the band used by systems operating in accordance with the provisions of RR 732, unless otherwise agreed by the affected administrations. In the part of the band where such systems are not operating, a mean value of -3 dB(W/4 kHz) is applicable.

(ii) <u>1525-1544/1626.5-1645.5 MHz & 1545-1559/1646.5-1660.5 MHz</u>

See Section 3.3.3 regarding the need for improving use of these bands.

(iii) <u>2483.5-2500 MHz</u>

RR No. 753F adopted at WARC-92 requires coordination of an MSS system in the 2483.5-2500 MHz band with terrestrial services under the provisions of Resolution 46 if the power flux density (PFD) exceeds the levels specified in RR No. 2566, which states that:

> The power flux-density at the Earth's surface produced by emissions from a space station, including emissions from a reflecting satellite, for all conditions and for all methods of modulation, shall not exceed the following values:
>
> > -152 dB(W/m^2) in any 4 kHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;
> >
> > -152 + 0.5(d-5) dB(W/m^2) in any 4 kHz band for angles of arrival d (in degrees) between 5 and 25 degrees above the horizontal plane;
> >
> > -142 dB(W/m^2) in any 4 kHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.
>
> These limits relate to the power flux-density which would be obtained under assumed free-space conditions.

For non-geostationary MSS systems, exceeding this PFD level may result in coordination being required with every one of the 160 or more members of the ITU, which would add substantial cost and delay to the implementation of non-GSO MSS systems in this band However, strict compliance with the RR No. 2566 PFD limits results in significant capacity limitations and inter-system coordination constraints, particularly in areas served by MSS satellites with elevation angles between about 15 and 25 degrees where the satellite power is constrained by the RR No. 2566 levels and not the inter-system coordination constraints.

Since WARC-92, substantial analysis has been undertaken which demonstrates that these PFD limits are unduly stringent with regard to non-geostationary MSS systems. Thus, these limits should be increased to facilitate the introduction of non-geostationary MSS systems. Relaxation of these values will not only accommodate non-geostationary MSS systems, but will also continue to meet protection requirements for analog point-to-point and multipoint fixed systems as recommended by the ITU-R. Moreover, an increase in the values will enable MSS systems to proceed without triggering unnecessary and time consuming coordination which would also impact the fixed service providers.

Recent analysis of the impact of the proposed operation of non-geostationary MSS systems on fixed services operating in the 2483.5-2500 MHz band demonstrates that typical CDMA non-GSO MSS operations at the higher PFD proposed will meet the protection requirements recommended by the ITU-R to safeguard the operation of analog point-to-point and multipoint fixed systems. See, Draft New Recommendation ITU-R IS. [Document 2/6]. These analyses demonstrates that operation of CDMA non-GSO MSS systems with characteristics similar to those proposed by the U.S. non-GSO MSS applicants within these PFD limits would not cause harmful interference into analog line-of-sight radio relay systems.

The report of Radiocommunication Sector TG 2-2 states that:

> there appears to be some sharing margin available between certain MSS and fixed service systems which have not been fully exploited. First, Non-GSO MSS satellite systems have more system design variables than GSO MSS systems. For example, Doc. 2-2/26 indicates the influence of spot beam use on non-GSO MSS satellites in improving the possibility of sharing. Also, Doc. 2-2/31 show how system pfd levels can be improved by taking account of the orbital transmission characteristics of a particular system. Doc. 2-2/27 indicates how the pfd level can be improved as a consequence of the statistical properties of the system implemented.

The technical studies performed to date include simulations of interference into various types of analog and digital point-to-point and multipoint fixed systems, and analyses of the potential impact on these systems. The results show that interference to almost all 2,500 km analog radio relay routes will be within values contained in Recommendation ITU-R F.357 for the higher proposed PFD levels. However, digital radio relay systems may be significantly impacted at these higher PFD levels. However, within the United States, there are few grandfathered fixed service systems operating in the 2483.5-2500 MHz, and the majority of fixed systems in this band are analog. For the affected digital systems, they may employ various techniques, such as increased power, to mitigate any interference effects. Thus, few fixed service systems would be impacted by increasing the PFD level in the band. Moreover, this proposal affects only a small band segment available to the fixed service in this portion of the spectrum, and sensitive digital fixed systems requiring greater interference protection can be located in portions of the band not allocated to MSS.

3.3.2 Feasibility of MSS Sharing

3.3.2.1. MSS Sharing with Space Services

a. Sharing among MSS networks

MSS networks employing narrow band channels with frequency division multiple access (FDMA) or time division multiple access (TDMA) techniques cannot share frequencies on a co-coverage basis (band segmentation is used to achieve sharing). Co-frequency, co-coverage sharing may be possible between MSS networks using FDMA or TDMA and networks using a limited number of code division multiple access (CDMA) channels. MSS networks employing CDMA can share on a co-frequency, co-coverage basis with capacity constraints that increase with the number of such co-frequency networks.

b. Sharing with the space operation service

The space operation (space-to-Earth) service shares the 1525-1535 MHz band with MSS (space-to-Earth). Protection criteria for, and information on spectrum usage by, space operation systems are given in Recommendation ITU-R SA.363-5, which notes that integration of space operation functions with data transmission or communication links (i.e., in other bands) has a number of advantages, including spectrum utilization efficiency, and that this is the normal practice. The Recommendation also notes that the necessary bandwidth of space operation links typically range between 200 kHz and 1 MHz. Thus, the space operation service poses only modest sharing constraints, particularly in the case of systems making temporary or exceptional use of MSS allocations.

c. Sharing with the meteorological-satellite (space-to-Earth) service

The meteorological-satellite (space-to-Earth) service shares the 1675-1710 MHz band with MSS (Earth-to-space) in Region 2. ITU-R Working Party 7C has completed a draft new Recommendation regarding the sharing between meteorological-satellite service (space-to-Earth) and MSS (Earth-to-space) in the 1675-1710 MHz band (Recommendation ITU-R SA. [Document 7/14]). The general conclusion of the Recommendation is that sharing is possible under certain conditions noting the following:

• that additional studies are required to further clarify the specific sharing conditions between earth stations and between space stations in the meteorological-satellite service and MSS;

• that a separation distance of approximately 40 km may be required to prevent co-channel interference to a meteorological-satellite earth station from a mobile earth station (this separation distance is considerably reduced when mobile earth stations transmit on channels adjacent to those used by meteorological-satellite earth stations);

• that for more than 20 years the international group of meteorological satellite operators (CGMS) has agreed to use the 1675 - 1710 MHz band in the following manner:

> 1675-1690 MHz - main earth stations at fixed locations for reception of raw image data, data collection transmissions and spacecraft telemetry from geostationary meteorological satellites.
>
> 1690-1698 MHz - user stations for direct data readout services from geostationary meteorological satellites.
>
> 1698-1710 MHz - user stations for direct data readout and pre-recorded image data at main earth stations from non-geostationary meteorological satellites.

d. Sharing with the fixed-satellite service

After 1 January 2005, the fixed-satellite (space-to-Earth) service will be co-primary in the 2500-2520 MHz band with MSS (space-to-Earth). Also after 1 January 2005, the fixed-satellite (Earth-to-space) service will be co-primary in the 2670-2690 MHz band with MSS (Earth-to-space). Until 1 January 2005, MSS use of these bands and the adjacent 2520 - 2535 MHz and 2655-2670 MHz bands is subject to agreement obtained under RR Article 14. In establishing these co-primary allocations, WARC-92 recognized that sharing is feasible.

3.3.2.2. MSS sharing with the radio astronomy service

The 1610.6-1613.8 MHz and 1660.0-1660.5 MHz bands are shared between radio astronomy and MSS (Earth-to-space). Several applicable ITU-R Recommendations have been adopted for the protection of radio astronomy, including RA.1031 for identifying situations where frequency assignments for mobile earth stations should be coordinated with those of a radio astronomy receiver. Several techniques are under development for the achievement of efficient sharing on the basis of time, frequency and geographic separation. Although the separation distances required for co-channel sharing can exceed 100 km, depending on the e.i.r.p. of mobile earth stations, radio astronomy observatories are deployed with low geographic density and they do not operate at all times. Thus, this sharing situation poses local constraints on mobile earth station operations in some areas.

3.3.2.3. Sharing with the fixed service

Most of the bands allocated to the MSS in the 1-3 GHz range are also allocated to